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CHIME ages of xenotime, monazite and zircon from beryllium pegmatites in the Napier Complex, Khmara Bay, Enderby Land, East Antarctica

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Abstract: Dating by the chemical Th-U-total Pb isochron method (CHIME) was carried out on xenotime, monazite and zircon from beryllium pegmatites intruded at about 2500 Ma in the ultrahigh-temperature metamorphic Napier Complex. No meaningful results were obtained on zircon from an associated Be-free pegmatite. All analyzed mineral grains are chronologically heterogeneous, and apparent ages range from ~2460 Ma to 550 Ma with conspicuous concentration at 2200, 1700 and 700 Ma. The 2168±36 Ma age for the chronologically homogeneous, non-metamict core of a large xenotime grain dates intense post-emplacement deformation and metamorphism, possibly the granulite-facies event M-2 proposed by E.S. Grew *et al.* (Polar Geosci., **13**, 1, 2000) to explain the breakdown of sapphirine and quartz to sillimanite, surinamite, orthopyroxene and/or garnet in the pegmatites and their host rocks. CHIME ages near ~1700 Ma and ~700 Ma could result from incomplete resetting by amphibolite-facies events (M-3, -4) between ~1100 and ~500 Ma. In general, the minerals appeared to have experienced no significant new growth during the later events, so that the effect of these events is expressed in the U-Th-Pb system in the original mineral. Because most of the ages were obtained on non-metamict portions of the analyzed grains, we doubt that metamictization can be the cause of most of the observed chronological heterogeneity. The lack of evidence for the ~2500 Ma emplacement age in the CHIME data could be due to the reliance on total concentrations of Th, U and Pb, which may be more affected by subsequent deformation and metamorphism than the isotope ratios measured in conventional U-Pb dating.

key words: pegmatite, beryllium, Antarctica, Archean, CHIME dating, Napier Complex

1. Introduction

The Napier Complex has had an extended history of crust formation and tectonothermal activity beginning in the early Archean and extending into the early Paleozoic (*e.g.*, Sheraton *et al.*, 1987; Harley and Black, 1997). Two relatively well-defined events include metamorphism, pegmatite intrusion and deformation at ~2500 Ma and ~500 Ma; the latter is most intense in the exposures along the south coast of Khmara and Casey Bays (Fig. 1; Sandiford, 1985; Harley, 1985). Less well defined in the Napier

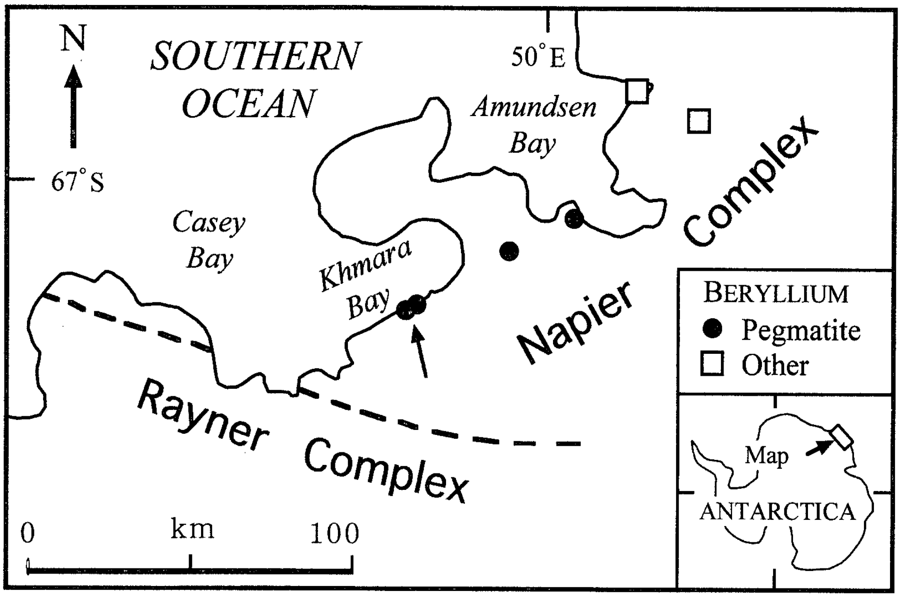

Fig. 1. Map of western Enderby Land showing location of the beryllium pegmatites at "Christmas Point" (arrow) relative to the boundary between the Rayner and Napier Complexes (simplified from Sheraton et al., 1987). "Beryllium" refers to occurrences of Be-rich minerals (Grew et al., 2000).

Complex are events between 2500 and 500 Ma, although the Rayner Complex to the south was affected by a major event at ~1000 Ma. Comparable ages in the Khmara Bay area include lead loss ages of 1000 to 1100 Ma (Black *et al.*, 1983, 1984; Grew, 1998) and a chemical Th-U-total Pb isochron method age of 1094±67 Ma on monazite in pegmatite from "Zircon Point" (Asami *et al.*, in review). Because the undeformed and unmetamorphosed Amundsen Dykes that intrude the Napier Complex are older (1190±200 Ma, Sheraton and Black, 1981; Sheraton *et al.*, 1987), it appears unlikely that the effect of the 1000–1100 Ma event extended beyond the Khmara Bay area and other areas near the boundary between the Napier and Rayner Complexes.

We selected for chemical Th-U-total Pb isochron method (CHIME) dating three samples (Table 1) containing xenotime, monazite, and zircon collected from two beryllium pegmatites (Grew *et al.*, 2000) at "Christmas Point" on JARE-40. Zircon grains in a fourth sample (no. 12234, a pegmatite lacking Be minerals) were analyzed, but they contain too little U and Pb to give meaningful results (Appendix). The polymetamorphic rocks at this locality, which is the southern extremity of one of the Field Islands in Khmara Bay, were affected by ultrahigh-temperature metamorphism in the late Archean and subsequently by amphibolite-facies events, most likely, between ~1100 and ~500 Ma. The beryllium pegmatites at "Christmas Point" are presumed to be 2500 Ma in age. Upper intercepts with concordia gave 2500 Ma ages for zircons from pegmatites of the same generation at a nearby locality on "Christmas Point" (Black *et al.*, 1983) and on "Zircon Point" and McIntyre Island (Grew *et al.*, 1982; Grew 1998). Our objective was to obtain more evidence for the 1000–1100 Ma event and, if possible, more data that could clarify unresolved questions in the complex metamorphic and deformational history of "Christmas Point".

2. Description of the analyzed samples

Sample no. 12212 (Table 1) consists largely of gray medium-grained quartz, red coarse-grained microcline-perthite, yellow-brown apatite, and brown sillimanite, the last in chatoyant prisms up to 5 cm by 4 cm. Subordinate constituents include olive-colored biotite replacing microcline, as well as fine-grained sapphirine (to 0.07 mm long) and rare kyanite (prisms to 1.2 mm long) enclosed in microcline. Fine-grained prismatic sillimanite is aggregated with quartz in microcline. Apatite forms medium-grained aggregates that enclose monazite, wagnerite and coarse-grained xenotime (to 6 mm long); nonetheless xenotime is locally in contact with quartz and microcline (Fig. 2A). The coarse-grained xenotime is optically zoned: a brown core is surrounded by a paler margin of variable thickness.

Wagnerite is more abundant is sample no. 12213, and, together with apatite, is a major constituent of the matrix. Xenotime (to 0.5 mm across) is most commonly surrounded by apatite and wagnerite; contacts with quartz and biotite are few (Fig. 2B, C and D). Microcline forms medium-grained aggregates. Biotite is dark-brown; its aggregates do not appear to be replacing microcline.

In contrast to most samples of the beryllium pegmatites, plagioclase is the dominant feldspar in sample no. 12268, which consists largely of gray quartz, gray and yellowish coarse-grained plagioclase (to 3 cm across), subordinate red microcline (to 6 cm across)

Table 1. Minerals in the studied samples.

Sample Number	12212	12213	12268
Pegmatite number[1]	1	1	2
Quartz	X	X	X
Microcline (Mc)	X	X	T
Plagioclase	–	–	X
Cordierite	–	T	–
Sillimanite	X	X	X
Kyanite	T	–	T
Garnet	–	–	X
Sapphirine (Spr)	–	–	T
Spr in Mc	T	–	–
Zircon	–	T	T
Biotite	X	X	X
Chlorite	–	–	T
Pyrite	–	T	–
Unid. opaque	T	–	T
Rutile	–	T	X
Hematite	–	(?)	–
Ilmenite	–	(?)	–
Spinel	–	–	T
Apatite	X	X	T
Wagnerite	T	X	–
Monazite	T	–	T
Xenotime	X	T	–

Note: Sample numbers are prefixed EG990-. X–major constituent; T–trace constituent.

[1]Pegmatite numbers refer to Grew *et al.* (2000, Table 1).

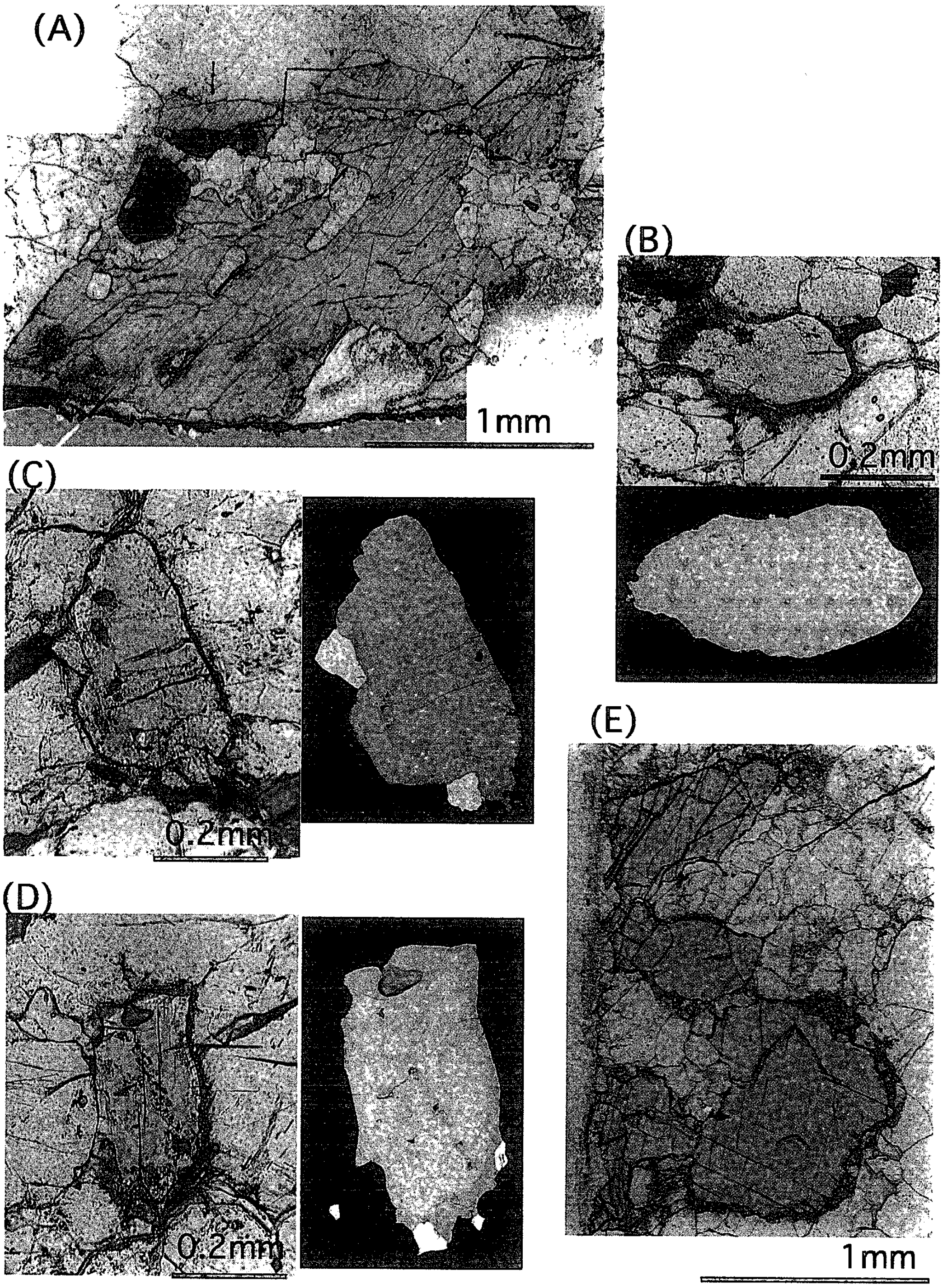

Fig. 2. (A) Photomicrograph in transmitted light of a large xenotime grain in sample 12212. The illustrated portion of the xenotime grain is surrounded largely by microcline and plagioclase with a subordinate amount of quartz. Metamict portions are damaged significantly by the electron beam bombardment (dark spots). (B) Photomicrograph in transmitted light and scanning electron microscope image of X07 xenotime grain surrounded by apatite and wagnerite in sample 12213. This grain was little injured by the electron beam bombardment, and appears to be free from intense metamictization. (C) and (D) Photomicrographs in transmitted light and back-scattered electron images (BSE) of X09 and X10 xenotime grains with distinct Th-poor margins surrounded by apatite and wagnerite in sample 12213. The bright grains next to xenotime in the BSE images are monazite. (E) Photomicrograph in transmitted light of monazite grains (M01-M05) in sample 12268. Lower grains are free from intense metamictization, whereas parts of the upper grains are metamict.

and garnet-biotite aggregates. Plagioclase is locally antiperthitic; its grains are commonly bent and granulated. In the portion of the sample sectioned, fine-grained microcline occurs sparingly at the margins of the coarse plagioclase grains. Brown biotite, together with rare kyanite and sillimanite, appears to be replacing garnet. Sillimanite is more common as prisms to 1 mm across in patches of medium-grained plagioclase formed by granulation of the coarse plagioclase. Apatite occurs sparingly. Monazite occurs as tiny grains at the margin of a plagioclase grain, and a coarse-grained monazite is found in an aggregate of relatively fine-grained microcline, plagioclase and quartz (Fig. 2E).

All three samples show ample evidence for at least two metamorphic events following original crystallization of the pegmatite. Grew *et al.* (2000) inferred that wagnerite, coarse-grained chatoyant sillimanite and a K-feldspar, which subsequently inverted to perthitic microcline, were pegmatitic phases; sapphirine was also an original phase that was preserved as inclusions in microcline. Medium-grained prismatic sillimanite, kyanite, surinamite, garnet and biotite in the analyzed samples are later phases that formed during a superimposed granulite-facies event M-2 and two later amphibolite-facies events (M-3, -4). Textures suggest that xenotime, monazite and zircon are also pegmatitic minerals; whereas the apatite margins around xenotime might be later. An important difference between no. 12212 and no. 12213 is that xenotime is much finer-grained in the latter sample, which could have made the U-Th-Pb system in xenotime more vulnerable to resetting.

3. CHIME data

3.1. Methods

Monazite, zircon, and xenotime were analyzed in polished thin sections with a JEOL JXA-733 microprobe analyzer equipped with four wavelength-dispersive spectrometers. Instrument operating conditions were 15 kV accelerating voltage, 0.3 μA beam current and 5 μm beam diameter. The ThM_α, UM_β, PbM_α and YL_γ lines were simultaneously measured with the PET crystal for analysis of monazite and zircon. The YL_γ interference of PbM_α becomes severe for xenotime, and thus the PbM_β line was used instead. X-ray intensity was integrated over a 200-s period for the line-peak position and a 100-s period for two optimum positions on both sides of each line-peak. For the zircon analysis, X-ray intensity was integrated over a 300-s period. The measurement was repeated twice, and the arithmetic average was taken as the true intensity. The detection limit of PbO at the 2σ confidence level is 0.01–0.006 wt% for monazite and xenotime and 0.003 wt% for zircon, and the relative error in the PbO determination is 5–10% at the 0.1 wt% concentration level and is much better for the higher concentrations. The X-ray intensity data were converted into concentrations by the Bence and Albee (1968) method. The small difference in the matrix between the reference materials and the samples has little effect on the ThO_2, UO_2 and PbO determinations; the maximum error in this calculation, about 0.5% of the concentration, is less than the uncertainty in the X-ray counting. Further details on the standards, analytical method, and age calculation method are given by Asami *et al.* (1998, in review) and references cited therein.

3.2. Results

A total of 197 spots were analyzed on a relatively coarse-grained xenotime (X1) in sample 12212 (Fig. 2A). Data can be resolved into three major age groupings for which the following CHIME ages were calculated (Fig. 3; Appendix):

(1) 2154±53 Ma (52 data with apparent ages of >2100 Ma, MSWD=0.18) on a chronologically homogeneous, non-metamict center (inclination: 0.3671±0.0119, intercept value: −0.0134±0.0365; maximum error in UO_2^*=±0.125, error in PbO=±0.045).

(2) 1640±52 Ma (50 data with apparent ages of 1600–1450 Ma, MSWD=0.84) on a chronologically homogeneous and non-metamict margin (inclination: 0.2602±0.0101, intercept value: −0.0397±0.0212; maximum error in UO_2^*=±0.088, error in PbO=±0.022)

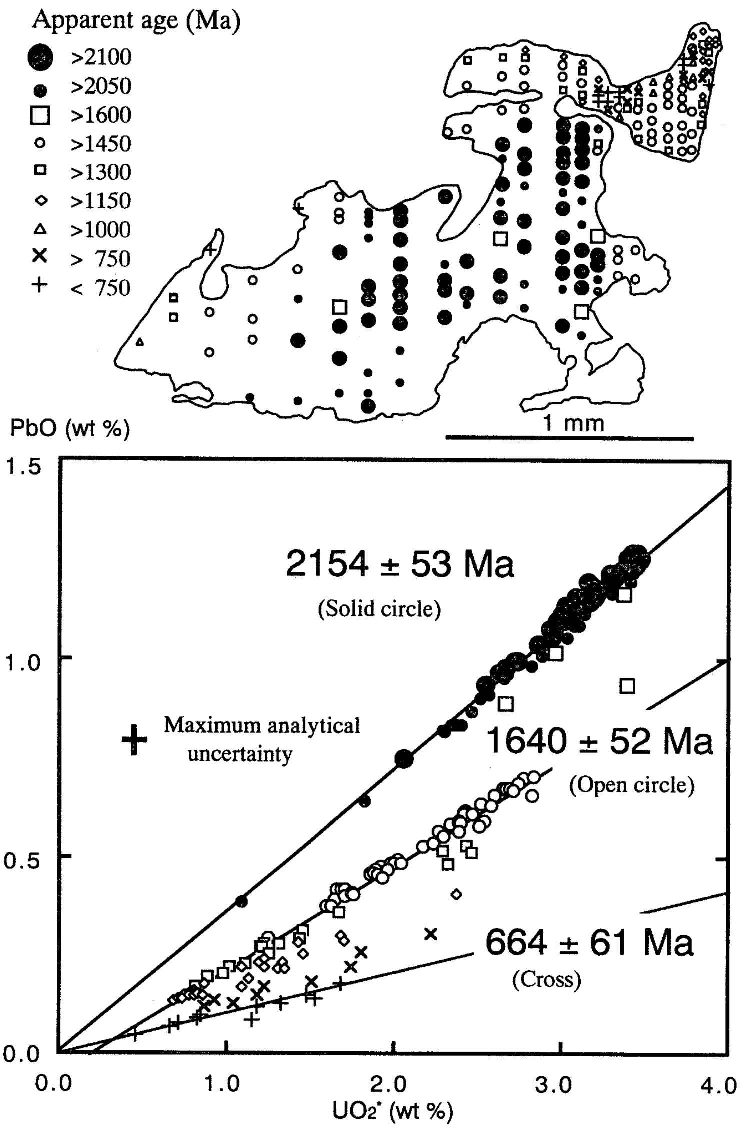

Fig. 3. Sketch of X01 xenotime grain from sample 12212 showing zoning in apparent age, with UO_2-PbO plot. The error given to the ages is of 2σ.*

(3) 664±61 Ma (MSWD=0.82) on marginal portions (inclination: 0.0941±0.0093, intercept value: −0.0018±0.0100; maximum error in UO_2^*=±0.064, error in PbO=±0.014).

Ten grains of xenotime were analyzed in sample no. 12213 (Fig. 4). The homogeneous center of non-metamict X07 grain gave a CHIME age of 1796±114 Ma (36 spots with apparent ages older than 1600 Ma, MSWD=2.71, inclination=0.2912±0.0230, intercept value=−0.0545±0.0854, maximum error in UO_2^*=±0.127, error in PbO=±0.042). Compatible ages were obtained form a small grain (X05) included in quartz (1694–1728 Ma apparent ages) and chronologically homogeneous cores of the relatively large X09 (1815±58 Ma, 46 analytical data) and X10 (1775±66 Ma, 52 analytical data) grains. The regression of 134 analyses with apparent ages older than 1600 Ma on centers of large X07, X09 and X10 grains yields a 1819±48 Ma age. The

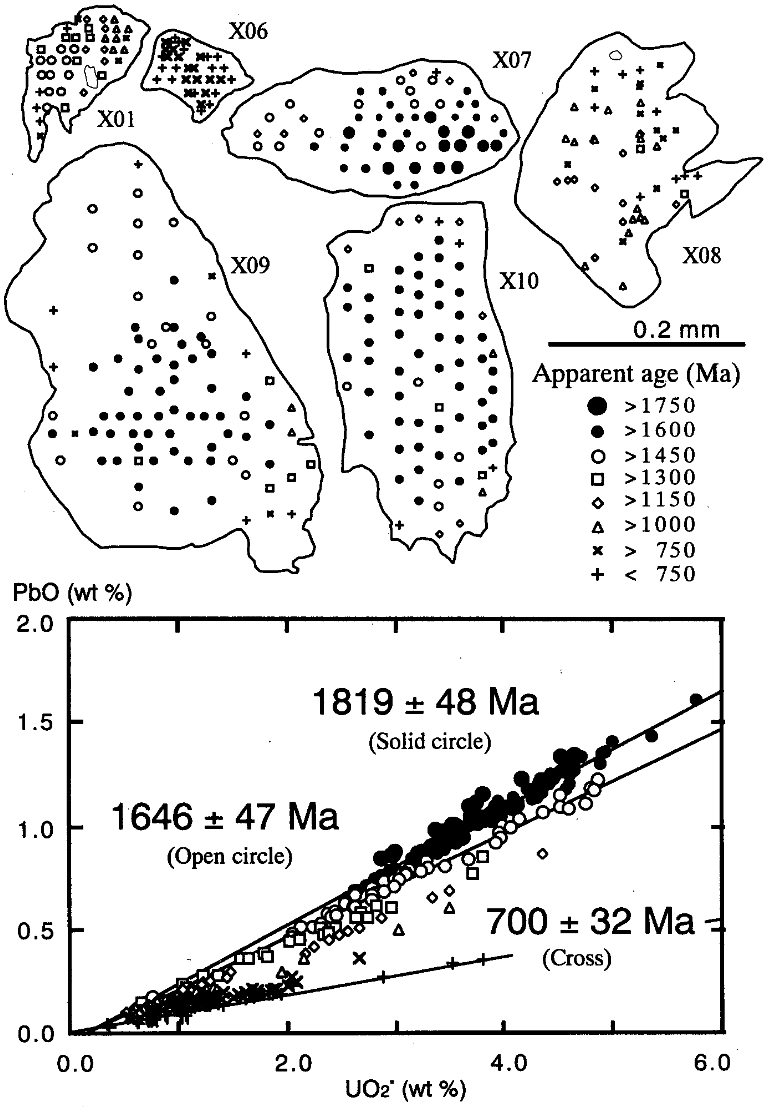

Fig. 4. Sketch of X01, X06, X07, X08, X09 and X10 xenotime grains from sample 12213 showing zoning in apparent age, with UO_2-PbO plot. The error given to the ages is of 2σ.*

homogeneous margins of large grains and the homogeneous centers of small grains (open circle in Fig. 3) give an age of 1646±47 Ma (47 data points, MSWD=2.38, inclination=0.2616±0.0090, intercept value=−0.0646±0.0266, maximum error in UO_2^*=±0.111, error in PbO=±0.031). Small xenotime grains have much younger apparent ages throughout the grains; a total of 34 data on X06 grain yield an isochron of 771±53 Ma (MSWD=1.39; inclination=0.1104±0.0083, intercept value=−0.0061±0.0104; maximum error in UO_2^*=±0.062, error in PbO=±0.015). Fifty-two analyses with apparent ages younger than 750 Ma on the margins of all 10 grains gave 700±32 Ma (MSWD=1.68; inclination=0.0995±0.0049, intercept value=0.0018±0.0066; maximum error in UO_2^*=±0.070, error in PbO=±0.015).

Monazite grains in sample 12268 are chronologically heterogeneous (Fig. 5); apparent ages range from 1860 to 560 Ma with exceptionally younger ages (280–500 Ma) for Th-rich metamict portions. A total of 52 spots were analyzed on 2 zircon grains. Two spots show apparent ages of 2440 and 2460 Ma, and the rest are in the range from 2300–1850 Ma. Regression of the 2300–1850 Ma data points yields a CHIME ages of

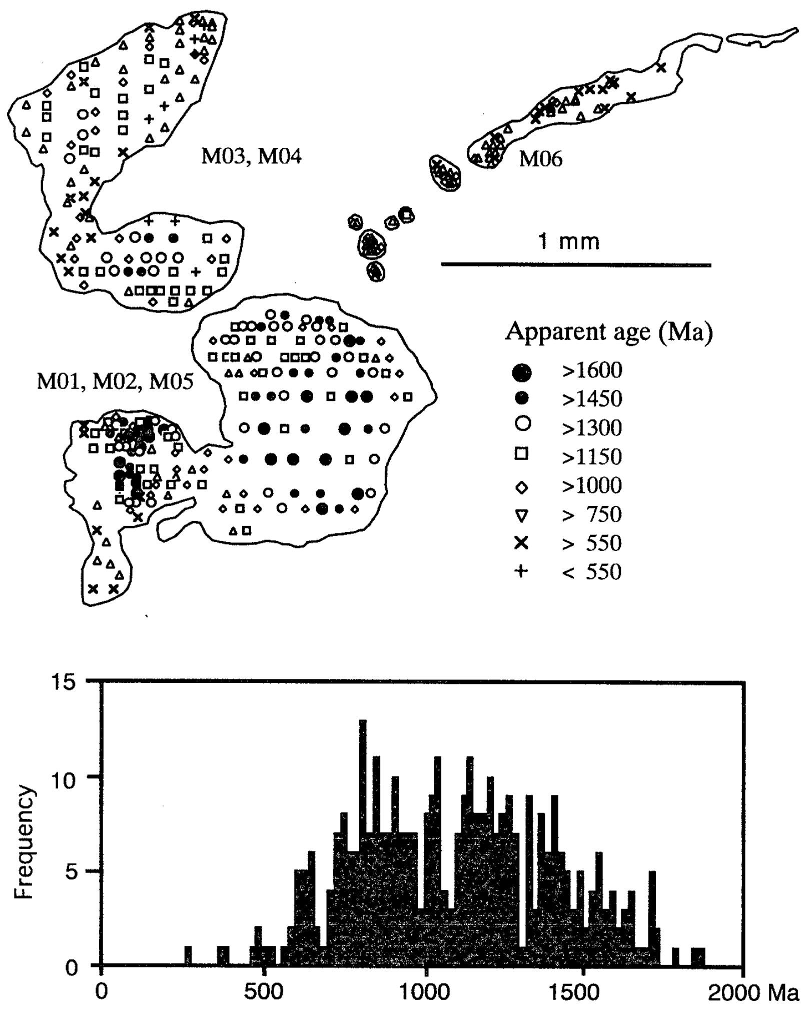

Fig. 5. Sketch of monazite grains from sample 12268 showing zoning in apparent age, with a histogram of apparent ages.

2222±55 Ma (MSWD=0.23; inclination=0.3829±0.0126, intercept value=−0.0013 ±0.0011; maximum error in UO_2^*=±0.029, error in PbO=±0.011).

In summary, the CHIME data record events at the following times: ~2200 Ma (xenotime core, zircon); ~1700 Ma (more xenotime), and ~700 Ma (more xenotime). However, there are many apparent ages in the range 600–1800 Ma for xenotime, and CHIME ages were calculated for what appeared to be concentrations of apparent ages.

4. Discussion

The new CHIME data are only in partial agreement with previously reported geochronologic data for Khmara Bay and elsewhere in the Napier Complex. Events at 2500, 1000–1100 Ma ("Rayner") and 500 Ma are not apparent in the new CHIME data.

There is no evidence in our CHIME data for events older than 2300 Ma, which is consistent with xenotime, monazite and zircon crystallizing from a pegmatitic melt at 2500 Ma and not being entrained restite from country rock that is significantly older.

However, the CHIME ages of about 2200 Ma are considerably younger than the 2400–2440 Ma CHIME ages on metamorphic monazite and zircon presumed to date the ultrahigh-temperature event (Asami *et al.*, 1998, in review). A simple explanation may be that the beryllium pegmatites were intruded after the ultrahigh-temperature event. However, this is unlikely, because the beryllium pegmatites have the same structural and mineralogical features as pegmatites at nearby localities in the Khmara Bay area dated at ~2500 Ma by U-Pb ages on zircons (Black *et al.*, 1983, 1984; Grew *et al.*, 1982; Grew, 1998). For example, the beryllium pegmatites have the same distinctive coarse sillimanite prisms as "an 'old' folded sillimanite pegmatite" on "Christmas Point" dated at 2456 Ma by Black *et al.* (1983, p. 285). In addition, no investigator has reported emplacement of high-temperature pegmatites after the emplacement of undeformed mafic dikes at ~2350–2400 Ma (Sheraton and Black, 1981; Sheraton *et al.*, 1987).

Another explanation more in accord with field relationships is that intense post-emplacement deformation and metamorphism at "Christmas Point" disrupted completely the U-Th-Pb system analyzed by the CHIME. The chronologically uniform core of large X01 xenotime grain in sample 12212 might have been rejuvenated during that event. That is, the 2168±36 Ma CHIME age for the core dates post-emplacement deformation and metamorphism, possibly the granulite-facies event (M-2) proposed by Grew *et al.* (2000) to explain the breakdown of sapphirine and quartz to sillimanite, surinamite, orthopyroxene and/or garnet in the pegmatites and their host rocks. An age near 2200 Ma is more plausible for this event than an age near 1100 Ma. Asami *et al.* (in review) suggested the latter as a distant possibility although they realized the difficulty posed by the 1190±200 Ma age for unmetamorphosed and undeformed Amundsen Dykes from several localities in the Napier Complex (Sheraton and Black, 1981; Sheraton *et al.*, 1987). The M-2 overprint was more intense at "Christmas Point" than at "Zircon Point" and the other localities studied by Asami *et al.* (1998, in review), and it is unlikely that the U-Th-Pb system in their samples was seriously disrupted by events after 2400 Ma except in a orthopyroxene quartzofeldspathic granulite from Mt. Riiser-Larsen. Citing a conspicuous concentration of apparent ages at about 2200 Ma in chronologically heterogeneous monazite grains from this granulite, Asami *et al.* (1998, in review) suggested that Mt. Riiser-Larsen might have been affected by high-temperature activity at ~2200 Ma.

The apparent ages younger than 2000 Ma suggest that several other events also affected the beryllium pegmatites at "Christmas Point"; these could correspond to the amphibolite-facies events M-3 and M-4 of Grew *et al.* (2000). Previous studies suggest ages between ~1100 (Rayner) and ~500 Ma for these events (Black *et al.*, 1983; Harley, 1985; Sandiford, 1985; Sheraton *et al.*, 1987). CHIME ages near ~1700 Ma and less than 750 Ma could result from incomplete resetting of the U-Th-Pb system during events between ~1100 and ~500 Ma, which were in the amphibolite facies and perhaps not hot enough to completely reset the ages in the relatively refractory mineral xenotime. It does not appear likely that the ~1700 age dates a specific event as previous studies have provided no evidence for an event at this time. We note that the absence of a clearcut imprint from the Rayner event could be due to the weakness of this event at "Christmas Point" and its being largely obliterated by the ~500 Ma event, explanations Black *et al.* (1983) cited for its absence in zircon data in a gneiss from "Christmas Point".

In conclusion, chronological heterogeneity most likely resulted from partial resetting of the U-Th-Pb system in the original minerals during tectonothermal events following intrusion of the pegmatites. Because most of the ages were obtained on non-metamict portions of the analyzed grains, we do not think metamictization played an important role in resetting the U-Th-Pb system in the analyzed grains. This resetting could have affected smaller grains more than larger grains, resulting in the different ages obtained for coarse-grained xenotime in no. 12212 and fine-grained xenotime in no. 12213. Apparently the minerals experienced no significant new growth during the later events, so that the effect of these events is expressed in the U-Th-Pb system in the original mineral. The lack of evidence for the emplacement age in the CHIME data could be due to the reliance on total concentrations of the measured elements for dating. Isotope ratios measured in conventional U-Pb dating of zircon and monazite (*e.g.*, Black *et al.*, 1983, 1984; Grew *et al.*, 1982) could be more robust than total U, Th, and Pb contents of xenotime and monazite analyzed by CHIME, and thus less affected by subsequent deformation and metamorphism.

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Appendix. Microprobe ThO_2, UO_2 and PbO analyses, apparent ages and ThO_2 or UO_2* values of xenotime (X), monazite (M) and zircon (Z) in pegmatites from "Christmas Point".*

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
Xenotime					
Sample EG99012212					
X01,0092-2219	0.007	0.780	0.147	1244	0.782
X01,0092-2240	0.009	0.750	0.139	1223	0.752
X01,0118-2219	0.006	0.820	0.148	1195	0.821
X01,0118-2244	0.007	0.809	0.155	1261	0.811
X01,0118-2271	0.008	0.821	0.164	1309	0.823
X01,0118-2307	0.072	0.844	0.169	1286	0.865
X01,0118-2350	0.006	0.865	0.112	887	0.867
X01,0118-2399	0.008	0.852	0.0898	737	0.854
X01,0143-2188	0.011	0.805	0.141	1166	0.808
X01,0143-2239	0.006	0.982	0.196	1311	0.983
X01,0143-2265	0.019	1.10	0.214	1278	1.10
X01,0143-2303	0.019	1.19	0.228	1261	1.20
X01,0143-2349	0.019	1.13	0.183	1085	1.14
X01,0143-2376	0.010	1.19	0.141	818	1.19
X01,0143-2449	0.014	1.22	0.214	1164	1.23
X01,0143-2484	0.016	1.21	0.265	1414	1.21
X01,0143-2519	0.018	1.22	0.234	1261	1.23
X01,0143-2566	0.023	1.22	0.273	1435	1.23
X01,0181-2202	0.012	0.686	0.130	1248	0.689
X01,0181-2259	0.010	0.831	0.144	1151	0.834
X01,0181-2283	0.007	0.925	0.126	929	0.927
X01,0181-2312	0.009	1.10	0.162	1000	1.10
X01,0181-2368	0.012	1.34	0.226	1130	1.34
X01,0181-2409	0.021	1.59	0.372	1492	1.60
X01,0181-2459	0.027	1.64	0.387	1503	1.65
X01,0181-2514	0.020	1.66	0.412	1574	1.66
X01,0181-2607	0.030	1.68	0.412	1549	1.69
X01,0181-2669	0.018	1.75	0.399	1463	1.76
X01,0223-2295	0.012	0.716	0.0671	658	0.720
X01,0223-2324	0.015	0.830	0.0805	680	0.834
X01,0223-2364	0.020	1.22	0.161	901	1.23
X01,0223-2388	0.013	1.42	0.277	1278	1.43
X01,0223-2423	0.010	1.71	0.412	1535	1.71
X01,0223-2464	0.021	1.86	0.456	1558	1.86
X01,0223-2501	0.018	1.88	0.465	1567	1.89
X01,0223-2575	0.024	1.86	0.457	1562	1.86
X01,0223-2628	0.029	1.86	0.454	1551	1.86
X01,0223-2678	0.036	1.91	0.475	1570	1.92
X01,0282-2372	0.010	1.31	0.210	1079	1.31
X01,0282-2411	0.014	1.63	0.371	1461	1.63
X01,0282-2446	0.013	1.74	0.403	1483	1.75
X01,0282-2490	0.055	2.26	0.563	1573	2.27
X01,0282-2577	0.048	1.99	0.481	1532	2.01
X01,0282-2626	0.043	1.98	0.480	1539	1.99
X01,0282-2672	0.031	1.43	0.287	1309	1.44
X01,0343-2388	0.006	1.35	0.208	1040	1.35
X01,0343-2434	0.020	1.70	0.281	1105	1.71
X01,0343-2502	0.078	2.42	0.615	1594	2.44
X01,0343-2552	0.083	2.41	0.606	1582	2.43
X01,0343-2606	0.089	2.37	0.588	1562	2.39
X01,0343-2641	0.082	2.31	0.579	1574	2.34
X01,0406-2409	0.007	1.46	0.246	1130	1.46
X01,0406-2436	0.018	1.75	0.213	842	1.75
X01,0406-2473	0.046	2.29	0.513	1440	2.30
X01,0406-2508	0.135	2.74	0.694	1583	2.78
X01,0406-2575	0.114	2.49	0.633	1589	2.53
X01,0406-2623	0.094	2.30	0.478	1340	2.33
X01,0448-2423	0.007	1.51	0.174	802	1.51
X01,0448-2475	0.043	2.21	0.297	916	2.23
X01,0448-2502	0.096	2.46	0.508	1339	2.48
X01,0485-2438	0.006	1.54	0.132	609	1.54
X01,0485-2457	0.012	1.69	0.170	705	1.69
X01,0485-2503	0.059	2.22	0.532	1520	2.24
X01,0485-2536	0.099	2.36	0.401	1128	2.38
X01,0525-2433	0.011	1.15	0.0758	471	1.16
X01,0525-2473	0.006	1.48	0.139	661	1.48
X01,0525-2507	0.022	1.80	0.252	954	1.81
X01,0567-2380	0.007	0.753	0.142	1241	0.755
X01,0567-2423	0.011	1.04	0.118	791	1.04
X01,0567-2449	0.009	1.19	0.113	665	1.19
X01,0567-2473	0.006	1.33	0.119	631	1.33
X01,0567-2587	0.197	3.38	1.19	2056	3.43
X01,0567-2647	0.170	1.41	0.309	1378	1.46
X01,0567-2675	0.125	2.63	0.671	1595	2.66
X01,0567-3026	0.201	3.36	0.931	1702	3.41
X01,0567-3108	0.172	3.14	1.18	2173	3.19
X01,0567-3144	0.174	3.13	1.19	2191	3.17
X01,0567-3202	0.161	3.05	1.08	2076	3.09
X01,0567-3248	0.130	2.87	1.00	2054	2.90
X01,0482-3084	0.113	2.37	0.586	1553	2.40
X01,0482-3128	0.126	2.45	0.607	1556	2.48
X01,0482-3190	0.142	2.52	0.587	1477	2.55
X01,0413-3086	0.039	1.92	0.442	1472	1.93
X01,0413-3203	0.120	2.40	0.610	1591	2.43
X01,0630-2316	0.006	0.777	0.142	1214	0.778
X01,0630-2352	0.016	1.21	0.265	1407	1.22
X01,0630-2399	0.019	1.87	0.456	1549	1.88
X01,0630-2446	0.015	1.68	0.355	1375	1.68
X01,0630-2472	0.016	1.69	0.293	1159	1.69
X01,0630-2584	0.190	3.37	1.22	2106	3.42
X01,0630-2623	0.197	3.36	1.25	2150	3.41
X01,0630-2673	0.203	3.39	1.26	2149	3.44
X01,0630-2727	0.204	3.42	1.26	2132	3.47
X01,0630-2804	0.200	3.41	1.26	2143	3.46
X01,0630-2885	0.205	3.40	1.22	2094	3.45
X01,0630-2980	0.215	3.45	1.24	2092	3.50
X01,0630-3087	0.186	3.17	1.16	2124	3.22
X01,0630-3171	0.173	3.11	1.15	2148	3.15
X01,0630-3235	0.151	2.96	1.09	2136	2.99
X01,0630-3333	0.137	2.95	1.01	2019	2.98
X01,0630-3438	0.115	2.64	0.948	2097	2.67
X01,0710-2292	0.009	0.715	0.132	1218	0.717
X01,0710-2331	0.006	1.25	0.289	1479	1.25
X01,0710-2373	0.034	2.02	0.489	1539	2.03
X01,0710-2428	0.077	2.43	0.524	1392	2.45
X01,0710-2575	0.195	3.37	1.23	2120	3.42
X01,0710-2618	0.197	3.37	1.23	2122	3.43
X01,0710-2683	0.191	3.30	1.20	2121	3.34
X01,0710-2726	0.185	3.25	1.20	2139	3.30
X01,0710-2788	0.193	3.34	1.22	2121	3.39
X01,0710-2847	0.208	3.46	1.25	2099	3.51
X01,0710-2914	0.201	3.42	1.24	2115	3.47
X01,0710-3034	0.197	3.40	1.23	2107	3.46
X01,0710-3113	0.182	3.25	1.18	2113	3.29
X01,0710-3180	0.176	3.13	1.14	2115	3.18
X01,0710-3243	0.154	3.08	1.08	2060	3.12
X01,0710-3393	0.107	2.53	0.929	2136	2.56
X01,0863-2267	0.006	0.736	0.132	1188	0.737
X01,0863-2296	0.008	0.890	0.187	1365	0.892
X01,0863-2347	0.031	1.95	0.463	1511	1.96
X01,0863-2413	0.085	2.37	0.561	1501	2.39

Appendix. (continued).

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
X01,0863-2504	0.149	2.79	0.653	1481	2.83
X01,0863-2572	0.181	3.18	1.17	2128	3.22
X01,0863-2694	0.168	3.07	1.12	2125	3.11
X01,0863-2748	0.181	3.16	1.15	2106	3.21
X01,0863-2821	0.183	3.27	1.16	2074	3.31
X01,0863-2965	0.194	3.33	1.22	2129	3.38
X01,0863-3076	0.192	3.38	1.22	2106	3.43
X01,0863-3223	0.168	3.11	1.11	2092	3.15
X01,0863-3326	0.135	2.89	1.03	2085	2.93
X01,0955-2294	0.007	1.25	0.249	1304	1.26
X01,0955-2373	0.070	2.28	0.549	1528	2.30
X01,0955-2514	0.148	2.68	0.667	1560	2.72
X01,0955-2651	0.163	3.06	1.15	2172	3.10
X01,0955-2708	0.049	1.81	0.635	2067	1.83
X01,0955-2817	0.158	2.93	1.08	2138	2.98
X01,0963-2891	0.167	3.05	1.09	2085	3.09
X01,0963-2955	0.187	3.28	1.21	2137	3.32
X01,0963-3038	0.192	3.34	1.16	2039	3.39
X01,0963-3192	0.167	3.02	1.13	2160	3.07
X01,0963-3276	0.141	2.84	1.03	2103	2.88
X01,1102-2307	0.009	1.12	0.223	1309	1.12
X01,1102-2413	0.051	2.17	0.524	1532	2.18
X01,1102-2591	0.145	2.80	0.700	1567	2.84
X01,1102-3131	0.170	3.15	1.16	2128	3.20
X01,1102-3262	0.160	2.98	1.11	2149	3.02
X01,1102-3313	0.142	2.90	1.03	2080	2.94
X01,1178-2609	0.140	2.66	0.670	1575	2.70
X01,1191-2870	0.158	2.99	1.09	2123	3.03
X01,1191-3148	0.167	3.11	1.11	2092	3.15
X01,1191-3214	0.189	3.26	1.21	2147	3.30
X01,1191-3253	0.171	3.07	1.14	2146	3.12
X01,1191-3363	0.143	2.92	1.05	2103	2.96
X01,1373-2931	0.148	2.94	1.08	2132	2.98
X01,1373-2969	0.155	2.99	1.11	2156	3.03
X01,1373-3046	0.158	3.04	1.12	2133	3.08
X01,1373-3146	0.167	3.02	1.11	2135	3.06
X01,1373-3216	0.160	3.07	1.13	2139	3.11
X01,1373-3270	0.156	3.03	1.13	2150	3.07
X01,1373-3322	0.159	2.99	1.11	2144	3.04
X01,1373-3390	0.145	2.94	1.07	2123	2.97
X01,1373-3500	0.110	2.55	0.905	2077	2.58
X01,1373-3635	0.091	2.38	0.829	2051	2.41
X01,1502-2938	0.150	3.01	1.05	2055	3.05
X01,1502-2957	0.131	2.80	0.976	2052	2.83
X01,1502-2984	0.100	2.36	0.827	2063	2.38
X01,1502-3038	0.027	1.09	0.381	2069	1.09
X01,1502-3236	0.157	2.93	1.06	2115	2.97
X01,1502-3290	0.167	2.99	1.13	2173	3.04
X01,1502-3374	0.135	2.72	0.990	2118	2.75
X01,1502-3593	0.107	2.45	0.860	2060	2.48
X01,1502-3681	0.080	2.28	0.812	2087	2.30
X01,1502-3731	0.064	2.05	0.740	2111	2.07
X01,1624-2875	0.133	2.56	0.628	1544	2.59
X01,1624-2942	0.143	2.57	0.652	1586	2.61
X01,1624-2966	0.141	2.65	0.668	1580	2.68
X01,1624-3100	0.123	2.70	0.990	2132	2.73
X01,1624-3321	0.121	2.64	0.883	1983	2.68
X01,1624-3402	0.151	2.91	1.07	2140	2.95
X01,1624-3533	0.121	2.61	0.959	2136	2.64
X01,1624-3679	0.087	2.32	0.826	2084	2.35
X01,1788-2921	0.010	0.663	0.0597	635	0.665
X01,1788-3111	0.124	2.49	0.577	1472	2.52

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
X01,1788-3173	0.144	2.66	0.669	1573	2.70
X01,1788-3290	0.120	2.66	0.954	2096	2.69
X01,1788-3461	0.126	2.65	0.973	2134	2.68
X01,1788-3711	0.088	2.29	0.811	2077	2.31
X01,1972-3217	0.039	1.89	0.451	1520	1.90
X01,1972-3373	0.113	2.36	0.585	1561	2.39
X01,1972-3461	0.150	2.71	0.680	1571	2.75
X01,1987-3695	0.108	2.50	0.895	2092	2.53
X01,2146-3091	0.008	0.454	0.0397	616	0.457
X01,2146-3351	0.017	1.71	0.395	1484	1.71
X01,2146-3516	0.060	2.04	0.480	1500	2.05
X01,2301-3292	0.011	1.02	0.215	1375	1.02
X01,2301-3368	0.013	1.31	0.274	1360	1.32
X01,2435-3469	0.007	0.854	0.140	1103	0.856
Sample EG99012213					
X01,0552-0916	0.009	0.909	0.153	1128	0.912
X01,0564-0916	0.006	0.587	0.107	1205	0.588
X01,0580-0916	0.009	1.04	0.202	1275	1.04
X01,0589-0916	0.015	1.21	0.140	798	1.22
X01,0538-0925	0.006	0.573	0.0879	1037	0.575
X01,0550-0925	0.005	0.956	0.151	1064	0.957
X01,0562-0925	0.008	0.519	0.0905	1160	0.521
X01,0578-0925	0.005	1.22	0.270	1429	1.22
X01,0601-0925	0.016	1.41	0.122	612	1.41
X01,0540-0935	0.006	0.748	0.106	968	0.750
X01,0550-0935	0.008	0.921	0.150	1093	0.923
X01,0561-0935	0.010	0.641	0.0988	1039	0.644
X01,0577-0935	0.007	1.02	0.230	1448	1.03
X01,0592-0935	0.005	1.56	0.350	1446	1.56
X01,0602-0935	0.006	1.64	0.354	1402	1.64
X01,0543-0947	0.009	0.843	0.125	1005	0.846
X01,0554-0947	0.006	0.566	0.0911	1082	0.568
X01,0563-0947	0.011	0.801	0.148	1217	0.804
X01,0582-0947	0.007	1.48	0.285	1270	1.48
X01,0593-0947	0.012	2.03	0.459	1454	2.04
X01,0606-0947	0.016	2.23	0.510	1470	2.23
X01,0627-0947	0.011	2.02	0.436	1402	2.02
X01,0548-0959	0.006	0.799	0.102	877	0.801
X01,0563-0959	0.009	1.21	0.234	1270	1.22
X01,0590-0959	0.010	2.30	0.497	1404	2.30
X01,0601-0959	0.030	2.38	0.555	1492	2.39
X01,0616-0959	0.026	2.60	0.606	1489	2.61
X01,0627-0959	0.012	2.04	0.478	1502	2.04
X01,0565-0974	0.021	2.41	0.498	1349	2.41
X01,0598-0974	0.022	2.30	0.522	1461	2.30
X01,0617-0974	0.029	2.76	0.638	1482	2.77
X01,0626-0974	0.020	2.12	0.509	1530	2.12
X01,0584-0991	0.026	2.65	0.497	1237	2.66
X01,0606-0991	0.042	2.76	0.658	1520	2.77
X01,0618-0991	0.037	2.59	0.604	1490	2.60
X01,0629-0991	0.009	0.729	0.0717	690	0.732
X01,0603-1007	0.033	2.37	0.472	1303	2.38
X01,0621-1007	0.031	2.42	0.577	1521	2.43
X01,0632-1007	0.006	1.02	0.0991	684	1.02
X01,0629-1021	0.004	0.883	0.0771	618	0.884
X01,0629-1036	0.018	1.31	0.164	862	1.31
X02,0437-0224	0.009	1.04	0.142	932	1.04
X02,0430-0224	0.014	1.30	0.169	892	1.30
X02,0439-0228	0.007	0.642	0.105	1101	0.644
X02,0429-0228	0.005	0.592	0.115	1274	0.593

Appendix. (continued).

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
X02,0417-0228	0.010	1.81	0.364	1318	1.81
X02,0407-0228	0.009	2.33	0.467	1315	2.33
X02,0407-0236	0.019	2.16	0.376	1162	2.16
X02,0417-0236	0.013	2.23	0.410	1217	2.24
X02,0427-0236	0.005	1.79	0.379	1378	1.79
X02,0435-0236	0.009	0.683	0.112	1095	0.686
X02,0435-0244	0.011	1.89	0.186	690	1.89
X02,0426-0244	0.014	1.16	0.153	908	1.16
X02,0407-0244	0.012	0.755	0.0900	824	0.758
X03,0839-0706	0.006	1.22	0.139	790	1.22
X03,0832-0706	0.019	1.40	0.190	924	1.41
X03,0845-0711	0.009	0.766	0.126	1100	0.769
X03,0829-0711	0.010	0.704	0.127	1199	0.707
X03,0820-0711	0.006	0.696	0.117	1121	0.698
X03,0816-0719	0.007	0.649	0.139	1384	0.651
X03,0838-0719	0.006	0.679	0.106	1053	0.681
X03,0851-0724	0.011	0.864	0.154	1180	0.867
X03,0838-0724	0.004	0.792	0.141	1185	0.793
X03,0818-0724	0.004	0.718	0.131	1206	0.719
X03,0829-0731	0.010	0.751	0.171	1462	0.754
X03,0836-0731	0.008	0.827	0.159	1263	0.829
X04,0770-0853	0.011	1.06	0.0728	492	1.06
X04,0785-0839	0.016	1.83	0.178	684	1.84
X04,0771-0855	0.013	1.01	0.0766	539	1.02
X05,0188-0047	0.174	3.43	0.941	1694	3.47
X05,0195-0047	0.184	3.47	0.969	1717	3.52
X05,0195-0053	0.205	3.72	1.04	1716	3.77
X05,0191-0053	0.201	3.65	1.03	1728	3.71
X06,1017-0907	0.030	1.85	0.179	680	1.86
X06,1006-0912	0.026	1.61	0.185	792	1.62
X06,1013-0912	0.026	1.83	0.197	749	1.84
X06,1021-0912	0.025	1.73	0.173	703	1.73
X06,1027-0912	0.017	1.27	0.143	781	1.27
X06,1008-0919	0.032	1.75	0.177	705	1.76
X06,1019-0919	0.023	1.54	0.181	812	1.55
X06,1027-0919	0.030	1.89	0.205	754	1.90
X06,0973-0927	0.009	1.03	0.107	731	1.03
X06,0983-0927	0.010	0.775	0.0768	694	0.778
X06,0991-0927	0.011	0.956	0.109	793	0.959
X06,1013-0927	0.020	1.38	0.152	765	1.39
X06,1025-0927	0.021	1.85	0.199	750	1.85
X06,1030-0927	0.008	1.07	0.0994	652	1.08
X06,0966-0939	0.007	0.609	0.0492	573	0.611
X06,0979-0939	0.004	0.756	0.0621	584	0.757
X06,0998-0939	0.010	1.18	0.147	861	1.18
X06,1003-0939	0.006	1.24	0.137	768	1.24
X06,1016-0939	0.016	1.22	0.125	712	1.23
X06,1030-0939	0.018	1.56	0.165	738	1.57
X06,0959-0951	0.005	0.744	0.0752	709	0.745
X06,0970-0951	0.006	0.540	0.0622	798	0.542
X06,0981-0951	0.010	0.687	0.0861	863	0.690
X06,0994-0951	0.014	1.15	0.127	768	1.15
X06,1006-0951	0.009	1.31	0.142	754	1.32
X06,1020-0951	0.030	2.05	0.220	748	2.06
X06,1036-0951	0.027	1.27	0.128	700	1.28
X06,0975-0965	0.012	1.08	0.108	702	1.08
X06,0986-0965	0.006	1.03	0.113	762	1.03
X06,0997-0965	0.014	1.36	0.134	693	1.36
X06,0003-0965	0.017	1.49	0.161	754	1.50
X06,0981-0976	0.009	0.964	0.102	741	0.967
X06,0990-0976	0.008	1.29	0.141	760	1.29
X06,0990-0983	0.015	1.03	0.107	727	1.03

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
X07,0343-0644	0.023	1.66	0.177	741	1.67
X07,0367-0644	0.175	2.81	0.549	1267	2.86
X07,0329-0652	0.208	3.28	0.642	1268	3.34
X07,0346-0652	0.222	3.21	0.826	1597	3.27
X07,0380-0652	0.391	3.80	0.913	1499	3.91
X07,0311-0663	0.203	3.34	0.927	1703	3.40
X07,0370-0663	0.394	3.87	1.00	1596	3.98
X07,0400-0663	0.457	3.81	1.05	1672	3.94
X07,0423-0663	0.495	4.01	1.09	1653	4.14
X07,0302-0677	0.203	3.39	0.970	1748	3.44
X07,0318-0677	0.341	3.67	1.00	1670	3.76
X07,0338-0677	0.370	3.85	0.967	1557	3.95
X07,0365-0677	0.543	4.21	1.06	1551	4.36
X07,0392-0677	0.463	3.83	1.07	1694	3.96
X07,0423-0677	0.466	3.83	0.942	1522	3.96
X07,0495-0677	0.608	4.62	1.18	1569	4.79
X07,0282-0691	0.095	2.35	0.441	1227	2.38
X07,0301-0691	0.239	3.51	0.993	1730	3.57
X07,0324-0691	0.357	3.63	1.05	1749	3.72
X07,0324-0691	0.360	3.78	1.04	1678	3.88
X07,0348-0691	0.516	4.52	1.33	1773	4.65
X07,0365-0691	0.578	4.84	1.40	1741	5.00
X07,0382-0691	0.470	3.94	1.09	1676	4.07
X07,0402-0691	0.436	3.68	1.04	1711	3.80
X07,0423-0691	0.582	4.36	1.25	1718	4.52
X07,0481-0691	0.525	4.21	0.860	1297	4.36
X07,0516-0691	0.524	4.44	1.08	1508	4.59
X07,0274-0707	0.079	2.81	0.724	1615	2.83
X07,0309-0707	0.331	3.45	1.00	1758	3.54
X07,0335-0707	0.399	3.70	1.14	1833	3.81
X07,0374-0707	0.508	4.20	1.22	1746	4.34
X07,0400-0707	0.646	5.19	1.42	1658	5.36
X07,0433-0707	0.634	4.35	1.32	1806	4.52
X07,0464-0707	0.599	4.58	1.10	1494	4.74
X07,0501-0707	0.306	3.40	0.599	1148	3.49
X07,0529-0707	0.203	2.97	0.490	1089	3.03
X07,0280-0721	0.068	2.85	0.836	1795	2.87
X07,0294-0721	0.102	2.93	0.851	1777	2.96
X07,0317-0721	0.335	3.61	1.04	1753	3.70
X07,0334-0721	0.362	3.64	1.10	1806	3.74
X07,0358-0721	0.336	3.36	0.799	1487	3.45
X07,0382-0721	0.448	4.04	1.22	1810	4.16
X07,0405-0721	0.569	4.24	1.19	1693	4.40
X07,0439-0721	0.415	3.63	1.05	1744	3.75
X07,0470-0721	0.376	3.88	1.04	1642	3.98
X07,0506-0721	0.249	3.60	0.837	1470	3.67
X07,0528-0721	0.182	3.24	0.794	1539	3.29
X07,0320-0744	0.086	2.95	0.852	1775	2.97
X07,0339-0744	0.111	2.97	0.866	1786	2.99
X07,0365-0744	0.300	3.60	1.09	1817	3.68
X07,0393-0744	0.328	3.44	0.997	1755	3.52
X07,0416-0744	0.360	3.68	1.04	1719	3.78
X07,0439-0744	0.275	3.56	0.937	1625	3.64
X07,0365-0761	0.046	2.54	0.649	1609	2.55
X07,0383-0761	0.055	2.70	0.703	1632	2.72
X08,0565-0872	0.003	1.29	0.136	736	1.29
X08,0578-0872	0.004	1.82	0.178	685	1.83
X08,0578-0890	0.004	1.36	0.271	1306	1.36
X08,0587-0825	0.008	0.851	0.100	816	0.853
X08,0587-0875	0.004	0.341	0.0361	739	0.342
X08,0587-0901	0.007	1.44	0.264	1215	1.44
X08,0608-0805	0.005	0.954	0.0986	724	0.955

Appendix. (continued).

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*	Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
X08,0608-0825	0.010	1.13	0.162	971	1.14	X09,0183-0181	0.080	2.85	0.749	1643	2.87
X08,0608-0841	0.006	1.08	0.169	1058	1.08	X09,0183-0217	0.157	3.21	0.848	1641	3.25
X08,0608-0885	0.013	1.07	0.126	813	1.08	X09,0183-0278	0.230	3.50	0.924	1636	3.56
X08,0604-0757	0.009	1.15	0.155	923	1.15	X09,0183-0333	0.222	3.46	0.933	1663	3.52
X08,0624-0762	0.029	1.93	0.183	665	1.94	X09,0222-0047	0.022	2.80	0.669	1523	2.81
X08,0624-0776	0.007	0.998	0.131	903	0.999	X09,0222-0106	0.052	2.85	0.726	1604	2.86
X08,0624-0796	0.007	0.938	0.139	1008	0.940	X09,0222-0155	0.084	2.85	0.733	1613	2.87
X08,0624-0807	0.005	0.936	0.137	993	0.938	X09,0222-0193	0.110	2.59	0.682	1637	2.62
X08,0624-0828	0.011	0.955	0.173	1198	0.958	X09,0222-0208	0.152	3.20	0.842	1636	3.24
X08,0624-0844	0.008	1.06	0.211	1302	1.06	X09,0222-0240	0.203	3.27	0.857	1626	3.33
X08,0624-0894	0.007	0.989	0.103	725	0.991	X09,0222-0283	0.297	3.72	1.01	1670	3.80
X08,0624-0914	0.014	1.30	0.217	1113	1.31	X09,0222-0344	0.299	3.83	1.02	1639	3.91
X08,0642-0767	0.004	1.25	0.127	713	1.25	X09,0259-0986	0.006	1.28	0.127	695	1.29
X08,0642-0849	0.010	1.11	0.216	1276	1.12	X09,0259-0017	0.010	2.45	0.564	1480	2.45
X08,0642-0900	0.006	1.28	0.243	1253	1.28	X09,0259-0048	0.033	2.96	0.705	1516	2.97
X08,0642-0920	0.007	1.20	0.229	1257	1.20	X09,0259-0080	0.044	2.97	0.734	1564	2.98
X08,0642-0940	0.009	1.05	0.118	781	1.06	X09,0259-0123	0.074	2.76	0.697	1589	2.78
X08,0642-0985	0.009	0.994	0.163	1102	0.997	X09,0259-0166	0.140	3.12	0.801	1604	3.16
X08,0671-0763	0.004	1.04	0.108	724	1.05	X09,0259-0198	0.148	2.88	0.742	1609	2.92
X08,0671-0782	0.009	1.09	0.146	917	1.10	X09,0259-0278	0.400	4.01	1.09	1661	4.12
X08,0671-0801	0.004	1.14	0.113	695	1.14	X09,0259-0319	0.369	3.98	1.07	1654	4.08
X08,0671-0835	0.009	1.16	0.193	1112	1.16	X09,0259-0340	0.235	3.16	0.779	1539	3.23
X08,0671-0884	0.007	1.21	0.233	1268	1.21	X09,0306-0033	0.031	2.87	0.677	1506	2.88
X08,0671-0956	0.009	0.988	0.175	1180	0.990	X09,0306-0073	0.062	3.03	0.766	1593	3.05
X08,0692-0800	0.006	0.991	0.147	1009	0.992	X09,0306-0195	0.218	3.38	0.878	1611	3.44
X08,0692-0837	0.013	1.06	0.161	1031	1.06	X09,0306-0262	0.394	4.20	1.13	1645	4.31
X08,0692-0875	0.012	1.12	0.195	1163	1.12	X09,0347-0137	0.010	0.780	0.0599	547	0.783
X08,0710-0878	0.011	0.730	0.127	1157	0.733	X09,0347-0195	0.015	3.52	0.325	653	3.52
X08,0701-0833	0.011	0.946	0.153	1085	0.950	X09,0263-0154	0.135	3.34	0.856	1603	3.38
X08,0672-0833	0.011	1.15	0.193	1117	1.16	X09,0230-0154	0.105	3.05	0.765	1575	3.08
X08,0624-0833	0.005	1.10	0.176	1077	1.10	X09,0189-0172	0.080	2.87	0.731	1599	2.89
X08,0601-0833	0.003	1.23	0.164	911	1.24	X09,0214-0172	0.138	3.35	0.861	1607	3.39
X08,0632-0916	0.008	1.26	0.207	1099	1.26	X09,0245-0172	0.140	3.07	0.784	1597	3.11
X08,0625-0828	0.014	1.000	0.150	1016	1.00	X09,0280-0187	0.167	3.15	0.811	1606	3.19
X08,0625-0780	0.004	0.949	0.105	769	0.950	X09,0240-0187	0.129	2.87	0.736	1602	2.91
X08,0628-0906	0.008	1.35	0.207	1038	1.35	X09,0203-0187	0.143	3.24	0.828	1600	3.28
X08,0637-0930	0.014	1.20	0.184	1037	1.20	X09,0126-0293	0.025	2.82	0.607	1396	2.82
X08,0658-0803	0.010	1.21	0.189	1051	1.22	X09,0161-0293	0.089	3.06	0.761	1567	3.09
X08,0699-0860	0.005	0.997	0.145	987	0.999	X09,0184-0293	0.144	3.11	0.830	1654	3.15
X08,0699-0877	0.010	0.893	0.154	1152	0.896	X09,0208-0293	0.217	3.58	0.929	1613	3.64
X08,0681-0965	0.010	0.849	0.133	1055	0.852	X09,0244-0293	0.325	4.05	1.10	1668	4.14
X08,0620-0918	0.014	1.34	0.201	1017	1.34	X09,0259-0293	0.230	2.67	0.551	1319	2.74
X09,0080-0271	0.022	2.04	0.258	869	2.04	X09,0282-0293	0.388	4.12	1.17	1723	4.22
X09,0081-0296	0.030	2.62	0.551	1364	2.63	X09,0297-0293	0.402	4.16	1.17	1713	4.27
X09,0101-0236	0.017	1.93	0.289	1013	1.94	X09,0340-0293	0.471	4.38	1.14	1595	4.51
X09,0101-0262	0.027	2.15	0.353	1102	2.15	X09,0349-0264	0.465	4.76	1.29	1661	4.89
X09,0101-0310	0.054	2.67	0.574	1391	2.68	X09,0325-0264	0.166	1.63	0.207	853	1.68
X09,0101-0348	0.010	0.709	0.0560	561	0.712	X09,0288-0264	0.320	3.95	1.09	1696	4.03
X09,0101-0378	0.011	0.741	0.0570	547	0.744	X09,0265-0264	0.292	3.84	1.09	1726	3.92
X09,0123-0209	0.032	2.43	0.497	1333	2.44	X09,0249-0264	0.261	3.76	1.03	1685	3.83
X09,0123-0255	0.055	2.63	0.675	1614	2.64	X09,0227-0264	0.225	3.64	1.00	1692	3.70
X09,0123-0296	0.086	2.91	0.741	1600	2.93	X09,0194-0164	0.204	3.50	0.955	1683	3.55
X09,0123-0321	0.098	2.94	0.594	1315	2.96	X09,0167-0264	0.078	2.76	0.722	1634	2.79
X09,0123-0348	0.080	2.64	0.350	903	2.66	X09,0147-0264	0.041	2.55	0.485	1252	2.56
X09,0147-0181	0.042	1.87	0.195	727	1.88	X09,0149-0246	0.027	2.35	0.576	1554	2.36
X09,0147-0226	0.089	2.93	0.759	1623	2.95	X09,0174-0246	0.072	2.79	0.734	1644	2.81
X09,0147-0268	0.195	3.41	0.888	1619	3.46	X09,0191-0246	0.122	3.18	0.848	1657	3.22
X09,0147-0308	0.145	2.99	0.735	1547	3.03	X09,0206-0246	0.208	3.54	0.980	1702	3.60
X09,0147-0354	0.085	3.79	0.346	642	3.81	X09,0238-0246	0.225	3.54	0.967	1680	3.61
X09,0147-0385	0.051	2.88	0.258	632	2.89	X09,0260-0246	0.240	3.55	0.920	1609	3.62
X09,0183-0102	0.034	2.08	0.236	789	2.08	X09,0278-0246	0.250	3.65	1.02	1715	3.72
X09,0183-0144	0.029	2.53	0.625	1567	2.53	X09,0295-0246	0.267	3.80	1.05	1691	3.87

Appendix. (continued).

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
X09,0347-0246	0.347	4.04	1.03	1582	4.14
X09,0269-0220	0.173	3.48	0.962	1704	3.52
X09,0237-0220	0.202	3.82	1.05	1691	3.88
X10,0964-0911	0.049	2.47	0.465	1241	2.48
X10,0964-0930	0.104	3.21	0.872	1684	3.24
X10,0964-0950	0.192	3.71	1.01	1689	3.76
X10,0964-0980	0.438	4.26	1.22	1733	4.38
X10,0964-1006	0.490	4.31	1.24	1738	4.44
X10,0964-1032	0.032	1.88	0.206	763	1.88
X10,0975-0872	0.007	1.68	0.168	701	1.69
X10,0975-0895	0.324	4.24	1.20	1729	4.33
X10,0975-0917	0.405	4.61	1.32	1739	4.72
X10,0975-0962	0.488	4.52	1.30	1732	4.66
X10,0975-0987	0.469	4.44	1.17	1616	4.57
X10,0975-1013	0.495	4.47	1.29	1740	4.61
X10,0975-1039	0.428	3.69	0.840	1427	3.81
X10,0975-1056	0.317	3.41	0.677	1274	3.50
X10,0999-0774	0.004	1.62	0.155	674	1.62
X10,0999-0797	0.047	1.99	0.221	771	2.00
X10,0999-0820	0.167	3.38	0.946	1722	3.42
X10,0999-0848	0.305	4.34	1.21	1711	4.43
X10,0999-0872	0.285	3.87	1.11	1748	3.95
X10,0999-0897	0.344	4.38	1.24	1727	4.48
X10,0999-0921	0.351	4.37	1.22	1708	4.47
X10,0999-0946	0.464	4.40	1.26	1726	4.53
X10,0999-0979	0.628	5.59	1.60	1729	5.76
X10,0999-1021	0.556	4.71	1.22	1589	4.86
X10,0999-1045	0.554	4.79	1.35	1705	4.94
X10,0999-1090	0.034	1.71	0.182	740	1.72
X10,1020-0774	0.007	1.85	0.199	750	1.86
X10,1020-0793	0.114	2.91	0.777	1662	2.94
X10,1020-0812	0.162	3.36	0.921	1693	3.40
X10,1020-0839	0.260	4.02	1.13	1715	4.09
X10,1020-0861	0.260	3.72	1.03	1699	3.79
X10,1020-0895	0.310	4.18	1.16	1701	4.27
X10,1020-0927	0.359	4.30	1.20	1703	4.40
X10,1020-0968	0.357	3.61	0.760	1339	3.71
X10,1020-0990	0.425	4.15	1.12	1655	4.26
X10,1020-1019	0.553	4.75	1.34	1711	4.90
X10,1020-1049	0.588	4.66	1.17	1546	4.82
X10,1020-1072	0.616	4.34	1.09	1543	4.51
X10,1020-1101	0.019	1.79	0.181	710	1.79
X10,1041-0771	0.006	1.76	0.179	710	1.77
X10,1041-0810	0.133	3.16	0.863	1689	3.20
X10,1041-0830	0.166	3.31	0.905	1688	3.35
X10,1041-0850	0.238	3.90	1.02	1618	3.97
X10,1041-0871	0.253	3.70	1.01	1677	3.77
X10,1041-0912	0.344	4.56	1.26	1689	4.65
X10,1041-0942	0.363	3.95	0.992	1560	4.05
X10,1041-0984	0.478	4.47	1.23	1680	4.60
X10,1041-1010	0.449	4.25	1.20	1708	4.38
X10,1041-1034	0.495	4.47	1.19	1632	4.60
X10,1041-1066	0.472	4.28	1.19	1692	4.41
X10,1061-0774	0.016	1.86	0.191	721	1.86
X10,1061-0824	0.151	3.21	0.855	1652	3.25
X10,1061-0845	0.187	3.43	0.930	1676	3.48
X10,1061-0869	0.231	3.76	1.01	1661	3.82
X10,1061-0891	0.288	4.28	1.15	1651	4.36
X10,1061-0930	0.298	3.90	1.09	1703	3.98
X10,1061-0956	0.316	3.81	1.01	1633	3.89
X10,1061-0983	0.325	3.78	1.05	1702	3.87
X10,1061-1012	0.305	3.29	0.973	1783	3.37
X10,1061-1043	0.310	3.59	1.01	1708	3.68
X10,1061-1092	0.061	1.71	0.195	787	1.72
X10,1093-0822	0.041	2.11	0.444	1365	2.12
X10,1093-0854	0.165	3.28	0.873	1653	3.32
X10,1093-0875	0.213	3.63	0.996	1691	3.68
X10,1093-0900	0.272	3.95	1.08	1683	4.03
X10,1093-0919	0.257	3.63	1.00	1696	3.70
X10,1093-0952	0.250	3.63	1.00	1698	3.70
X10,1093-0997	0.249	3.59	0.985	1684	3.66
X10,1115-0802	0.020	1.84	0.193	734	1.84
X10,1115-0843	0.159	3.50	0.907	1615	3.55
X10,1115-0863	0.153	3.27	0.895	1690	3.32
X10,1115-0916	0.093	2.96	0.784	1648	2.99
X10,1115-0946	0.038	2.61	0.660	1597	2.62
			Monazite		
Sample GE99012268					
M1,3503-1698	8.29	0.277	0.593	1466	9.29
M1,3555-1703	8.28	0.284	0.579	1429	9.30
M1,3704-1746	6.37	0.440	0.440	1281	7.93
M1,3669-1746	8.15	0.256	0.553	1404	9.06
M1,3635-1746	8.00	0.294	0.555	1410	9.05
M1,3597-1749	8.17	0.269	0.586	1472	9.14
M1,3543-1749	8.21	0.266	0.524	1320	9.15
M1,3489-1749	8.17	0.276	0.570	1429	9.16
M1,3430-1749	8.14	0.278	0.402	1026	9.10
M1,3374-1749	7.45	0.343	0.529	1401	8.68
M1,3318-1749	8.17	0.441	0.418	1002	9.69
M1,3267-1749	7.95	0.426	0.519	1267	9.45
M1,3326-1721	7.49	0.535	0.629	1529	9.42
M1,3361-1721	7.56	0.534	0.599	1453	9.47
M1,3410-1721	7.44	0.475	0.547	1377	9.13
M1,3792-1804	7.63	0.457	0.398	1005	9.21
M1,3736-1804	5.69	0.496	0.447	1378	7.46
M1,3699-1804	6.81	0.323	0.458	1327	7.96
M1,3641-1804	7.96	0.288	0.487	1253	8.97
M1,3559-1804	8.02	0.292	0.466	1191	9.05
M1,3440-1804	7.96	0.300	0.481	1233	9.01
M1,3355-1804	7.98	0.319	0.517	1308	9.11
M1,3294-1804	7.82	0.333	0.535	1366	9.01
M1,3237-1804	7.80	0.309	0.671	1713	8.94
M1,3198-1804	7.50	0.585	0.669	1591	9.63
M1,3119-1804	8.35	0.610	0.508	1124	10.5
M1,3789-1875	8.03	0.408	0.501	1224	9.46
M1,3734-1875	6.63	0.457	0.454	1269	8.25
M1,3703-1875	6.33	0.459	0.399	1164	7.93
M1,3653-1875	8.06	0.377	0.344	859	9.34
M1,3615-1875	8.01	0.298	0.520	1322	9.06
M1,3499-1875	7.94	0.289	0.502	1291	8.96
M1,3461-1875	8.00	0.317	0.479	1215	9.12
M1,3417-1875	8.02	0.361	0.475	1182	9.28
M1,3375-1875	7.91	0.300	0.553	1415	8.99
M1,3293-1875	7.86	0.303	0.594	1522	8.96
M1,3241-1875	7.92	0.296	0.548	1404	8.97
M1,3183-1875	7.96	0.304	0.490	1252	9.03
M1,3138-1875	7.77	5.74	0.941	807	27.2
M1,3084-1875	8.07	0.442	0.461	1110	9.61
M1,3730-1934	8.34	0.332	0.331	814	9.47
M1,3689-1934	6.71	0.378	0.291	849	7.99
M1,3629-1934	7.91	0.330	0.447	1143	9.06
M1,3594-1934	7.90	0.290	0.467	1209	8.92

Appendix. (continued).

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
M1,3528-1934	7.85	0.277	0.522	1360	8.83
M1,3468-1934	7.82	0.284	0.592	1534	8.85
M1,3407-1934	7.78	0.278	0.598	1559	8.79
M1,3312-1934	7.82	0.278	0.519	1356	8.81
M1,3200-1934	7.79	0.289	0.596	1543	8.84
M1,3147-1934	7.80	0.314	0.543	1399	8.92
M1,3097-1934	7.51	0.525	0.493	1218	9.36
M1,3037-1934	8.36	0.616	0.464	1026	10.5
M1,3669-2032	8.15	0.581	0.563	1273	10.2
M1,3620-2032	7.27	0.404	0.600	1571	8.74
M1,3554-2032	7.93	0.301	0.595	1512	9.02
M1,3503-2032	7.80	0.323	0.550	1413	8.96
M1,3414-2032	7.74	0.268	0.651	1703	8.73
M1,3314-2032	7.69	0.270	0.455	1216	8.64
M1,3231-2032	7.83	0.265	0.635	1649	8.80
M1,3174-2032	7.76	0.272	0.635	1657	8.76
M1,3063-2032	7.83	0.293	0.435	1138	8.85
M1,3008-2032	8.09	0.532	0.519	1204	9.96
M1,3660-2160	7.29	0.453	0.515	1333	8.90
M1,3581-2160	7.60	0.283	0.649	1713	8.64
M1,3501-2160	7.79	0.299	0.497	1295	8.84
M1,3418-2160	7.55	0.271	0.556	1497	8.53
M1,3261-2160	7.69	0.283	0.617	1619	8.72
M1,3166-2160	7.70	0.309	0.609	1579	8.82
M1,3095-2160	7.81	0.292	0.525	1365	8.85
M1,3729-2290	7.62	0.354	0.384	1008	8.84
M1,3669-2290	7.28	0.316	0.535	1458	8.42
M1,3554-2290	7.71	0.285	0.630	1645	8.76
M1,3470-2290	7.68	0.276	0.661	1732	8.70
M1,3333-2290	7.64	0.269	0.657	1735	8.64
M1,3239-2290	7.70	0.298	0.490	1292	8.75
M1,3139-2290	7.60	0.310	0.499	1320	8.70
M1,3734-2423	7.99	0.484	0.334	810	9.62
M1,3670-2423	7.53	0.282	0.419	1138	8.51
M1,3561-2423	7.52	0.276	0.522	1411	8.51
M1,3460-2423	7.71	0.290	0.565	1480	8.76
M1,3355-2423	7.43	0.286	0.548	1485	8.46
M1,3208-2423	7.54	0.292	0.626	1660	8.61
M1,3151-2423	7.49	0.509	0.564	1395	9.31
M1,3748-2488	7.63	0.307	0.379	1013	8.69
M1,3682-2488	7.53	0.288	0.465	1256	8.54
M1,3609-2488	7.54	0.285	0.378	1028	8.53
M1,3508-2488	7.48	0.261	0.496	1358	8.40
M1,3422-2488	7.58	0.330	0.401	1066	8.72
M1,3347-2488	7.35	0.281	0.632	1719	8.39
M1,3280-2488	7.50	0.277	0.555	1497	8.50
M1,3217-2488	7.85	0.291	0.404	1059	8.85
M1,3710-2579	7.40	0.269	0.341	9 54	8.32
M1,3655-2579	7.41	0.269	0.462	1273	8.36
M2,4048-2127	7.11	0.304	0.557	1555	8.21
M2,4017-2136	7.42	0.277	0.524	1431	8.42
M2,4093-2172	7.04	0.326	0.559	1557	8.23
M2,4051-2172	7.02	0.293	0.656	1840	8.11
M2,3987-2172	7.41	0.304	0.613	1643	8.52
M2,3951-2172	7.37	0.282	0.524	1436	8.38
M2,4173-2195	6.25	0.475	0.337	994	7.88
M2,4131-2195	6.29	0.513	0.573	1606	8.16
M2,4085-2195	6.96	0.314	0.666	1861	8.14
M2,4046-2195	7.49	0.287	0.676	1798	8.56
M2,3973-2195	7.62	0.292	0.474	1264	8.65
M2,3939-2195	7.65	0.296	0.533	1408	8.71
M2,4162-2242	6.57	0.510	0.488	1339	8.38
M2,4132-2242	6.97	0.446	0.539	1445	8.57
M2,4078-2242	7.21	0.286	0.612	1691	8.26
M2,3929-2242	7.71	0.438	0.473	1181	9.25
M2,4118-2263	5.83	0.462	0.519	1581	7.51
M2,4077-2263	7.22	0.295	0.521	1445	8.28
M2,3944-2263	7.60	0.320	0.433	1150	8.71
M2,3811-2263	7.78	0.375	0.418	1068	9.08
M2,4082-2329	7.53	0.365	0.444	1165	8.81
M2,4027-2329	7.48	0.306	0.450	1215	8.55
M2,3936-2329	7.50	0.317	0.423	1137	8.61
M2,3877-2329	7.64	0.328	0.368	975	8.77
M2,3822-2329	7.66	0.346	0.439	1146	8.87
M2,4053-2388	7.33	0.336	0.424	1153	8.51
M2,4016-2388	7.33	0.329	0.401	1097	8.47
M2,3956-2388	7.31	0.308	0.445	1224	8.39
M2,3893-2388	7.43	0.322	0.417	1129	8.55
M2,3832-2388	7.43	0.343	0.430	1153	8.62
M2,4036-2431	7.24	0.330	0.413	1140	8.39
M2,3970-2431	7.29	0.332	0.338	934	8.43
M2,4033-2470	7.24	0.337	0.513	1399	8.44
M2,4096-2365	7.22	0.481	0.620	1582	8.97
M2,4096-2384	6.89	0.537	0.634	1637	8.86
M2,4096-2426	7.16	0.617	0.703	1701	9.44
M2,4096-2465	7.35	0.629	0.585	1403	9.60
M2,4122-2324	7.08	0.482	0.593	1537	8.83
M2,4122-2349	7.21	0.605	0.653	1587	9.41
M2,4122-2466	7.19	0.612	0.548	1348	9.37
M2,4122-2496	7.00	0.557	0.400	1041	8.92
M2,4164-2303	6.86	0.548	0.635	1638	8.86
M2,4164-2358	6.83	0.561	0.633	1629	8.88
M2,4164-2400	6.78	0.525	0.561	1486	8.67
M2,4164-2456	7.60	0.410	0.472	1207	9.04
M3,1227-8732	9.29	0.873	0.447	851	12.3
M3,1227-8752	10.0	0.555	0.427	837	11.9
M3,1227-8795	9.35	0.805	0.390	756	12.1
M3,1258-8726	11.5	0.552	0.447	779	13.4
M3,1255-8748	28.5	0.819	0.523	394	31.2
M3,1255-8789	10.1	0.531	0.496	967	11.9
M3,1255-8840	9.29	0.849	0.517	983	12.2
M3,1255-8870	9.33	0.732	0.521	1020	11.9
M3,1289-8722	9.72	0.819	0.382	716	12.5
M3,1289-8852	28.5	0.864	0.487	366	31.4
M3,1289-8794	42.5	0.991	0.556	287	45.8
M3,1289-8855	8.76	0.774	0.517	1048	11.4
M3,1289-8945	11.3	0.589	0.487	851	13.3
M3,1340-8727	9.26	0.844	0.440	846	12.1
M3,1340-8766	9.49	0.855	0.461	866	12.4
M3,1340-8814	9.76	0.832	0.437	810	12.6
M3,1340-8908	10.3	0.552	0.509	973	12.2
M3,1340-9011	10.4	0.526	0.419	803	12.2
M3,1295-8737	8.96	0.544	0.483	1034	10.8
M3,1395-8889	9.47	0.456	0.555	1161	11.1
M3,1395-8941	9.50	0.609	0.453	910	11.6
M3,1395-9047	25.6	0.404	0.603	526	26.9
M3,1395-9120	11.1	0.657	0.531	925	13.4
M3,1452-8754	10.00	0.609	0.386	749	12.0
M3,1452-8787	9.85	0.490	0.423	857	11.5
M3,1452-8827	9.42	0.425	0.519	1103	10.9
M3,1452-8871	9.49	0.425	0.578	1216	11.0
M3,1452-8984	9.33	0.426	0.546	1167	10.8
M3,1452-9095	27.2	0.396	0.565	467	28.5
M3,1452-9163	9.44	0.570	0.421	862	11.4

Appendix. (continued).

Spot No.	ThO2 (wt %)	UO2 (wt %)	PbO (wt %)	Age (Ma)	UO2* ThO2*
M3,1553-8820	6.33	0.592	0.331	922	8.35
M3,1553-8908	9.36	0.390	0.454	985	10.7
M3,1553-8957	9.55	0.384	0.494	1054	10.9
M3,1553-9020	9.22	0.387	0.554	1210	10.6
M3,1553-9081	9.24	0.373	0.546	1196	10.5
M3,1553-9138	9.36	0.391	0.551	1186	10.7
M3,1553-9219	11.4	0.952	0.416	669	14.5
M3,1650-8879	9.29	0.411	0.380	830	10.7
M3,1650-8997	9.32	0.388	0.531	1152	10.7
M3,1650-9069	9.27	0.382	0.523	1142	10.6
M3,1650-9138	9.36	0.394	0.470	1018	10.7
M3,1650-9219	9.26	0.386	0.563	1225	10.6
M3,1650-9331	9.55	0.808	0.342	653	12.3
M3,1693-8898	9.70	0.399	0.553	1153	11.1
M3,1693-8958	9.55	0.409	0.299	642	10.9
M3,1693-9077	9.54	0.378	0.625	1323	10.9
M3,1693-9159	9.33	0.400	0.617	1322	10.7
M3,1693-9209	9.50	0.403	0.557	1180	10.9
M3,1693-9284	9.68	0.513	0.386	789	11.4
M3,1693-9386	10.0	0.774	0.319	593	12.6
M3,1746-8928	7.15	0.605	0.447	1118	9.26
M3,1746-8970	9.56	0.404	0.392	836	10.9
M3,1746-9189	9.50	0.385	0.516	1103	10.8
M3,1746-9243	9.23	0.385	0.640	1388	10.6
M3,1746-9326	9.06	0.463	0.413	904	10.6
M3,1746-9390	9.61	0.510	0.279	579	11.3
M3,1746-9565	9.68	0.414	0.431	904	11.1
M3,1831-8997	9.49	0.414	0.479	1019	10.9
M3,1831-9044	9.43	0.384	0.537	1152	10.8
M3,1831-9090	9.54	0.403	0.616	1295	11.0
M3,1831-9160	9.55	0.403	0.597	1256	11.0
M3,1906-9042	9.69	0.435	0.431	898	11.2
M3,1906-9143	10.4	0.465	0.448	871	12.0
M3,1807-9517	10.2	0.437	0.365	730	11.7
M3,1758-9403	9.36	0.500	0.399	842	11.1
M3,1848-9208	9.90	0.395	0.470	971	11.3
M4,1685-0443	10.3	0.547	0.321	621	12.1
M4,1711-0458	9.84	0.476	0.537	1083	11.5
M4,1672-0458	9.56	0.590	0.384	776	11.6
M4,1721-0534	9.33	0.440	0.472	1010	10.9
M4,1666-0534	12.6	0.481	0.443	731	14.2
M4,1564-0534	10.2	0.716	0.545	1001	12.6
M4,1503-0534	9.04	0.325	0.588	1329	10.2
M4,1451-0534	9.25	0.326	0.661	1457	10.4
M4,1365-0534	9.11	0.352	0.710	1565	10.4
M4,1240-0534	9.15	0.572	0.568	1179	11.1
M4,1170-0534	9.49	0.627	0.572	1135	11.7
M4,1358-0477	27.5	0.374	0.601	491	28.8
M4,1452-0477	26.2	0.331	0.590	509	27.3
M4,1178-0609	9.30	0.557	0.586	1202	11.3
M4,1226-0609	9.49	0.500	0.546	1125	11.2
M4,1343-0609	9.23	0.350	0.620	1363	10.5
M4,1404-0609	9.17	0.348	0.620	1370	10.4
M4,1460-0609	9.00	0.333	0.620	1398	10.2
M4,1527-0609	8.39	0.313	0.464	1133	9.48
M4,1603-0609	9.08	0.330	0.606	1361	10.3
M4,1730-0609	9.25	0.318	0.478	1071	10.3
M4,1779-0609	9.80	0.518	0.321	651	11.5
M4,1751-0663	7.65	0.472	0.292	738	9.23
M4,1693-0663	7.67	0.477	0.472	1168	9.34
M4,1630-0663	9.38	0.472	0.621	1295	11.1
M4,1579-0663	9.11	0.350	0.644	1427	10.4
M4,1527-0663	8.76	0.308	0.654	1519	9.87
M4,1480-0663	8.78	0.320	0.674	1553	9.94
M4,1430-0663	8.67	0.280	0.588	1398	9.67
M4,1361-0663	8.98	0.281	0.543	1258	9.97
M4,1278-0663	25.8	0.292	0.558	489	26.8
M4,1185-0663	9.43	0.452	0.610	1276	11.0
M4,1237-0727	9.25	0.461	0.563	1197	10.9
M4,1301-0727	8.80	0.295	0.529	1240	9.84
M4,1360-0727	8.62	0.275	0.523	1258	9.59
M4,1409-0727	8.57	0.303	0.534	1276	9.64
M4,1448-0727	8.38	0.308	0.514	1252	9.47
M4,1486-0727	8.26	0.304	0.510	1261	9.33
M4,1531-0727	8.23	0.348	0.386	953	9.42
M4,1441-0769	8.30	0.346	0.434	1059	9.50
M4,1361-0769	8.28	0.322	0.502	1231	9.42
M4,1307-0769	8.59	0.566	0.434	959	10.5
M4,1696-0711	8.48	0.588	0.485	1068	10.5
M5,1542-1183	8.64	0.677	0.497	1050	11.0
M5,1568-1206	7.77	0.449	0.495	1224	9.35
M5,1518-1206	7.51	0.322	0.590	1555	8.68
M5,1454-1206	7.88	0.317	0.481	1234	8.99
M5,1660-1223	7.59	0.477	0.247	629	9.18
M5,1582-1223	7.89	0.410	0.329	826	9.28
M5,1534-1223	7.72	0.327	0.551	1425	8.89
M5,1478-1223	8.26	0.367	0.463	1122	9.54
M5,1436-1223	7.86	0.311	0.441	1142	8.94
M5,1423-1250	7.85	0.317	0.427	1104	8.95
M5,1459-1250	7.95	0.320	0.400	1023	9.06
M5,1512-1250	7.93	0.310	0.459	1178	9.02
M5,1567-1250	7.43	0.352	0.556	1467	8.70
M5,1619-1250	6.55	0.525	0.430	1185	8.39
M5,1658-1250	6.94	0.416	0.219	616	8.32
M5,1623-1301	6.72	0.501	0.476	1292	8.49
M5,1564-1301	7.28	0.307	0.460	1269	8.36
M5,1415-1301	8.06	0.471	0.376	905	9.67
M5,1322-1403	8.05	0.380	0.358	893	9.35
M5,1394-1403	7.95	0.341	0.322	825	9.11
M5,1531-1423	7.76	0.334	0.318	835	8.89
M5,1474-1484	7.50	0.365	0.303	809	8.74
M5,1529-1484	7.40	0.353	0.305	828	8.60
M5,1529-1441	7.47	0.344	0.344	925	8.65
M5,1613-1512	8.15	0.666	0.421	938	10.4
M5,1453-1482	7.71	0.336	0.281	742	8.84
M5,1611-1716	7.73	0.569	0.334	807	9.66
M5,1623-1828	7.44	0.518	0.266	677	9.18
M5,1547-1828	8.25	0.758	0.296	643	10.8
M5,1530-1772	7.37	0.444	0.344	900	8.89
M5,1563-1732	8.57	0.677	0.362	778	10.9
M5,1609-1609	8.20	0.490	0.292	693	9.84
M5,1578-1645	7.90	0.570	0.323	769	9.82
M5,1461-1560	8.19	0.363	0.257	641	9.40
M6,9446-3497	9.98	0.635	0.402	774	12.1
M6,9439-3501	9.38	0.634	0.485	975	11.6
M6,9435-3511	8.79	0.566	0.400	870	10.7
M6,9437-3525	9.07	0.667	0.358	739	11.3
M6,9443-3525	9.90	0.593	0.357	702	11.9
M6,9467-3389	9.99	0.642	0.552	1049	12.2
M6,9456-3389	9.92	0.594	0.500	972	12.0
M6,9473-3401	10.2	0.825	0.627	1114	13.0
M6,9462-3401	9.62	0.579	0.520	1038	11.6
M6,9450-3401	10.3	0.654	0.553	1021	12.6
M6,9475-3415	9.84	0.595	0.457	896	11.9

Appendix. (continued).

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
M6,9463-3415	8.78	0.516	0.384	850	10.5
M6,9451-3415	9.71	0.569	0.435	870	11.6
M6,9437-3415	10.2	0.634	0.469	884	12.4
M6,9422-3422	10.1	0.637	0.554	1048	12.3
M6,9434-3436	10.2	0.623	0.554	1039	12.4
M6,9449-3436	10.2	0.605	0.476	901	12.3
M6,9462-3436	10.3	0.642	0.509	947	12.5
M6,9475-3436	10.2	0.634	0.501	941	12.4
M6,9521-3327	10.0	0.649	0.463	882	12.2
M6,9510-3330	8.88	0.622	0.385	817	11.0
M6,9377-3323	10.0	0.606	0.493	945	12.1
M6,9321-3300	9.67	0.574	0.593	1174	11.7
M6,9215-3114	6.86	0.649	0.286	740	9.04
M6,9215-3128	8.84	0.671	0.448	936	11.1
M6,9190-3128	9.63	0.564	0.470	945	11.6
M6,9208-3143	10.0	0.673	0.481	907	12.3
M6,9167-3143	8.19	0.674	0.411	911	10.5
M6,9193-3158	9.71	0.437	0.528	1089	11.2
M6,9173-3158	10.1	0.460	0.421	844	11.6
M6,9145-3158	9.18	0.903	0.586	1102	12.3
M6,9185-3176	9.37	0.416	0.491	1053	10.8
M6,9167-3176	9.64	0.440	0.443	924	11.1
M6,9153-3176	9.47	0.775	0.417	805	12.1
M6,9162-3186	9.93	0.661	0.457	873	12.2
M6,9076-3090	8.89	0.686	0.388	807	11.2
M6,9059-3090	9.37	0.732	0.450	883	11.9
M6,9019-3090	9.48	0.626	0.448	897	11.6
M6,8997-3090	10.3	0.627	0.385	725	12.4
M6,9015-3110	9.18	0.643	0.382	785	11.4
M6,8997-3071	10.2	0.627	0.463	874	12.3
M6,9018-3071	10.7	0.623	0.504	917	12.8
M6,9066-3071	9.56	0.709	0.418	815	12.0
M6,9031-3041	10.0	0.701	0.422	794	12.4
M6,9003-3041	8.95	0.678	0.388	804	11.2
M6,8976-3041	8.67	0.655	0.352	756	10.9
M6,9000-3013	9.07	0.758	0.366	735	11.6
M6,8975-3013	9.48	0.700	0.396	780	11.8
M6,8953-2979	8.87	0.675	0.360	754	11.1
M6,8831-2916	8.51	0.616	0.298	659	10.6
M6,8792-2916	10.4	0.641	0.411	762	12.6
M6,8847-2943	8.21	0.616	0.276	630	10.3
M6,8680-2933	9.83	0.715	0.427	813	12.3
M6,8617-2902	9.06	0.542	0.364	780	10.9
M6,8751-2902	10.6	0.674	0.466	841	12.9
M6,8790-2902	8.65	0.635	0.419	901	10.8
M6,8815-2902	7.94	0.619	0.315	734	10.0
M6,8783-2872	9.93	0.621	0.546	1049	12.1
M6,8739-2872	9.98	0.626	0.439	845	12.1
M6,8705-2872	9.17	0.589	0.381	796	11.2
M6,8592-2899	8.93	0.536	0.276	604	10.7
M6,8690-2841	8.50	0.623	0.322	711	10.6
M6,8645-2836	8.62	0.622	0.291	636	10.7
M6,8601-2836	8.75	0.524	0.273	610	10.5
M6,8574-2802	8.79	0.497	0.285	639	10.5
M6,8568-2815	8.97	0.508	0.282	619	10.7
M6,8558-2804	9.17	0.506	0.275	594	10.9
M6,8496-2861	8.84	0.510	0.336	743	10.6
M6,8383-2749	8.20	0.501	0.259	616	9.87
M6,8706-2870	8.63	0.577	0.339	750	10.6
M6,8774-2882	10.0	0.576	0.538	1040	12.0
M6,8818-2917	9.05	0.628	0.338	708	11.2
M6,8791-2895	9.39	0.609	0.483	977	11.5

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
			Zircon		
Sample EG99012268					
Z01	0.003	0.269	0.103	2222	0.270
Z01	0.007	0.162	0.0541	1987	0.164
Z01	0.004	0.259	0.0971	2179	0.260
Z01	0.010	0.168	0.0596	2075	0.170
Z01	0.014	0.041	0.0168	2188	0.045
Z01	0.020	0.036	0.0150	2150	0.041
Z01	0.003	0.205	0.0824	2297	0.206
Z01	0.020	0.161	0.0644	2245	0.166
Z01	0.004	0.099	0.0341	2041	0.100
Z01	0.007	0.275	0.111	2304	0.276
Z01	0.008	0.280	0.111	2266	0.282
Z01	0.013	0.035	0.0126	1972	0.038
Z01	0.012	0.219	0.0889	2293	0.223
Z01	0.007	0.155	0.0583	2175	0.157
Z01	0.006	0.205	0.0817	2274	0.207
Z01	0.005	0.250	0.0924	2158	0.251
Z01	0.006	0.246	0.0998	2313	0.247
Z01	0.014	0.241	0.0964	2269	0.245
Z01	0.007	0.215	0.0808	2181	0.216
Z01	0.006	0.269	0.109	2304	0.270
Z01	0.004	0.216	0.0757	2073	0.217
Z01	0.006	0.079	0.0316	2262	0.081
Z01	0.004	0.266	0.0859	1943	0.267
Z01	0.008	0.272	0.102	2178	0.274
Z01	0.005	0.256	0.0984	2223	0.257
Z01	0.005	0.261	0.0839	1938	0.262
Z01	0.005	0.073	0.0286	2239	0.074
Z01	0.006	0.259	0.100	2226	0.261
Z01	0.005	0.224	0.0825	2146	0.226
Z01	0.005	0.197	0.0789	2283	0.199
Z01	0.005	0.246	0.0924	2180	0.247
Z01	0.004	0.148	0.0574	2228	0.149
Z02	0.003	0.105	0.0351	1990	0.106
Z02	0.016	0.037	0.0160	2249	0.041
Z02	0.017	0.051	0.0191	2063	0.055
Z02	0.020	0.050	0.0170	1886	0.055
Z02	0.013	0.044	0.0206	2460	0.047
Z02	0.018	0.047	0.0180	2085	0.051
Z02	0.009	0.052	0.0208	2218	0.054
Z02	0.018	0.047	0.0199	2226	0.052
Z02	0.016	0.047	0.0204	2308	0.051
Z02	0.011	0.050	0.0187	2091	0.053
Z02	0.007	0.049	0.0184	2131	0.051
Z02	0.012	0.052	0.0167	1859	0.055
Z02	0.011	0.060	0.0210	2013	0.062
Z02	0.015	0.056	0.0241	2316	0.060
Z02	0.017	0.039	0.0135	1912	0.043
Z02	0.017	0.053	0.0184	1944	0.057
Z02	0.014	0.036	0.0171	2439	0.039
Z02	0.010	0.056	0.0210	2126	0.058
Z02	0.010	0.051	0.0202	2204	0.053
Z02	0.013	0.046	0.0172	2066	0.049
Sample GE99012234 (not used)					
Z01-01	0.017	0.035	0.0113	1777	0.039
Z01-02	0.018	0.032	0.0029	559	0.037
Z01-03	0.016	0.033	0.0045	831	0.038
Z01-04	0.018	0.031	0.0063	1173	0.036
Z01-05	0.020	0.028	0.0072	1394	0.034
Z02-06	0.015	0.029	0.0074	1442	0.033

Appendix. (continued).

Spot No.	ThO_2 (wt %)	UO_2 (wt %)	PbO (wt %)	Age (Ma)	UO_2* ThO_2*
Z01-07	0.019	0.028	0.0055	1117	0.033
Z01-08	0.023	0.031	0.0086	1497	0.037
Z01-09	0.020	0.033	0.0044	785	0.039
Z01-10	0.021	0.035	0.0083	1335	0.041
Z01-11	0.016	0.029	0.0082	1571	0.033
Z01-12	0.017	0.027	0.0070	1412	0.032
Z01-13	0.017	0.032	0.0046	864	0.037
Z01-14	0.020	0.027	0.0056	1148	0.033
Z01-15	0.015	0.031	0.0045	880	0.035
Z01-16	0.021	0.035	0.0062	1019	0.041
Z01-17	0.021	0.036	0.0073	1173	0.042
Z01-18	0.018	0.033	0.0053	956	0.038
Z01-19	0.019	0.026	0.0080	1607	0.031
Z01-20	0.019	0.028	0.0067	1305	0.034
Z01-21	0.020	0.025	0.0066	1395	0.031
Z01-22	0.012	0.028	0.0048	1045	0.031
Z01-23	0.023	0.033	0.0085	1397	0.039
Z01-24	0.022	0.035	0.0053	882	0.041
Z01-25	0.017	0.028	0.0064	1285	0.033
Z01-26	0.020	0.033	0.0048	863	0.038
Z01-27	0.021	0.034	0.0086	1405	0.040
Z01-28	0.017	0.028	0.0054	1112	0.033
Z02-01	0.013	0.029	0.0035	734	0.033
Z02-02	0.016	0.031	0.0052	1004	0.035
Z02-03	0.016	0.026	0.0052	1143	0.030
Z02-04	0.014	0.027	0.0049	1084	0.030
Z02-05	0.013	0.027	0.0036	800	0.031
Z02-06	0.012	0.030	0.0060	1185	0.034
Z02-07	0.012	0.028	0.0030	666	0.032
Z02-08	0.013	0.027	0.0041	910	0.031
Z02-09	0.013	0.029	0.0062	1268	0.032
Z02-10	0.015	0.031	0.0071	1326	0.035
Z02-11	0.013	0.026	0.0061	1343	0.030
Z02-12	0.014	0.027	0.0038	842	0.031
Z02-13	0.024	0.038	0.0068	1030	0.045
Z03-01	0.007	0.026	0.0065	1478	0.028
Z03-02	0.010	0.026	0.0067	1501	0.029
Z03-03	0.004	0.035	0.0077	1382	0.036
Z03-04	0.015	0.027	0.0082	1642	0.031
Z04-01	0.016	0.029	0.0083	1570	0.034
Z04-02	0.020	0.031	0.0047	882	0.037

Note

UO_2*: sum of the measured UO_2 and UO_2 equivalent of the measured ThO_2 for xenotime and zircon.

ThO_2*: sum of the measured ThO_2 and ThO_2 equivalent of the measured UO_2 for monazite.

Analyzed position is shown for some grain in μm: *e.g.* X01,0092-2219 means 92 μm from right and 2219 μm from top.